Design Philosophy

WHEELER
CircuitRunners

Before we get started..

- A bit about me....
  - Did FLL/FRC and went to Wheeler (woot woot)
  - Have over two years of design experience at places such as BMW & Carbon3D (big additive guy right here)
  - I love bringing ideas to life... and want to help you do the same!
  - Georgia Tech ME 5th year Undergrad.. getting out this fall, wish me luck

- And what about you?
  - Why did you want to take this course?
  - If you could build one thing.. What would you want to build?

What is a Design Philosophy?

Guiding principles to help you follow engineering best practices as you create robots!

CircuitRunners Design Philosophy

Ours has **five** sections:

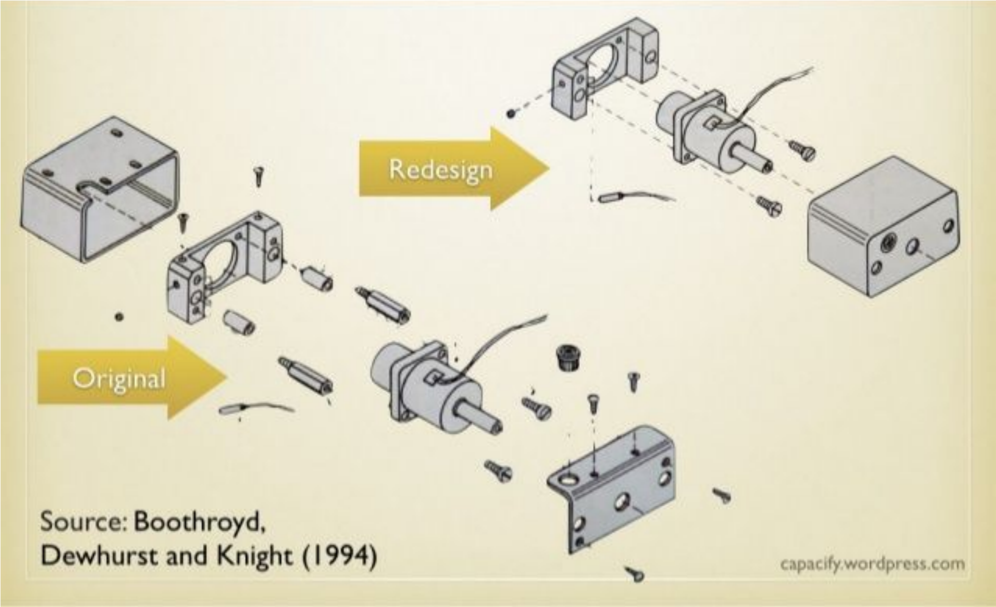
- **Ground Rules-** basic “sanity check” items to follow as you design
- **CAD Program**- our standards for designing virtually
- **Design Process**- how to go from idea to actual mechanism
- **Design Principles-** what to prioritize mechanically as you design mechanisms
- **Documentation Principles**- how to keep track of your progress as you go

These principles help ensure that what you design is competitive on the field!

Ground Rules

Rule #1

Keep it simple, stupid!



Rule #2

Steal the best, invent the rest (thanks FRC 1678!)

How to do:

- https://grabcad.com/library/tag/frc
- https://www.google.com/search?q=frc+robot+cad
- https://cad.onshape.com/documents?nodeId=3&resourceType=filter&q=_all:frc%20robot
- https://blog.thebluealliance.com/tag/behind-the-design/

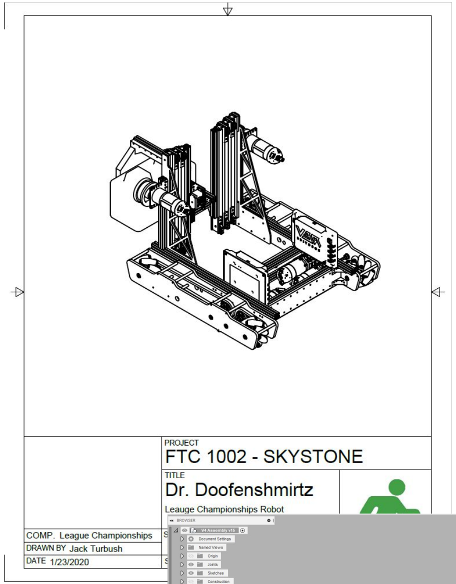
(can do same with FTC)

CAD

CAD Program

- CAD stands for *Computer-Aided Design*
- Many Robotics teams use CAD to visualize their robot design before manufacturing the parts and assembling their robot
- In CAD, documentation is always necessary. CAD softwares give plentiful tools to help you create *technical drawings.*

Using your technical drawings, anyone should be able to recreate your design with ease.



2D sketch

Part

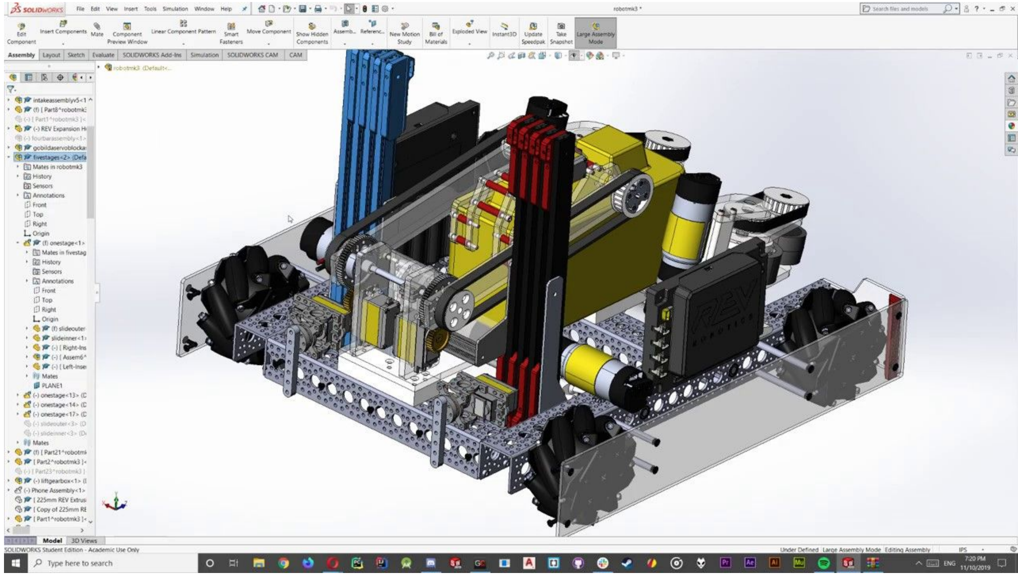
Assembly

CAD Program

We use SOLIDWORKS

(and also OnShape for this camp)

Solidworks is the **industry standard** in professional 3D modeling.



The unbiased scale of CAD program excellence

good	eh	BAD
SOLIDWORKS		Paint 3D

Design Process

Design Process Overview

Design happens along a spectrum:

Pure CAD

(fully virtual)

Pure Tinkering

(fully tactile)

Design Process Overview

We are aiming to be here:

90% CAD

10% Tinkering

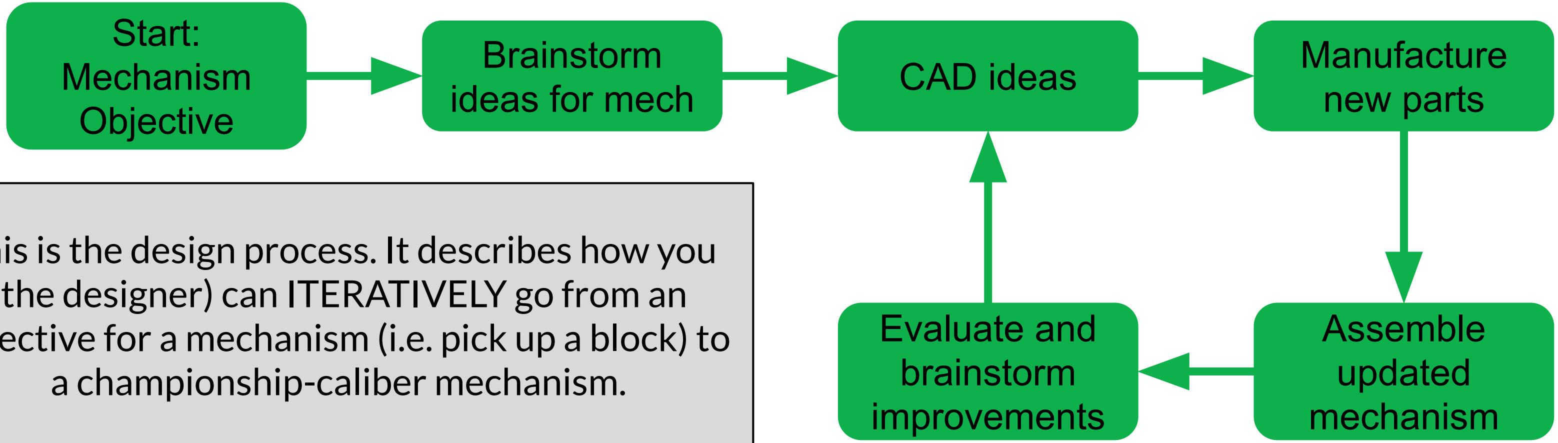
Pure CAD

(fully virtual)

Pure Tinkering

(fully tactile)

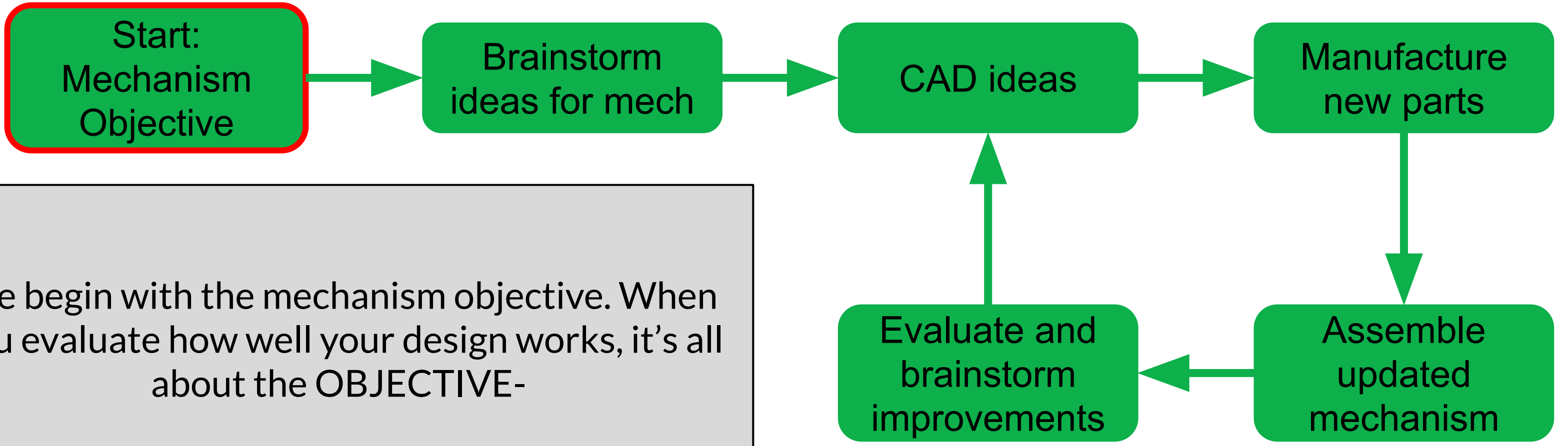
Design Process Workflow



This is the design process. It describes how you (the designer) can ITERATIVELY go from an objective for a mechanism (i.e. pick up a block) to a championship-caliber mechanism.

Note that **strategy** decisions (i.e. what game objectives you decide are the ones you'll pursue) happen outside this process but are very important!

Design Process Workflow

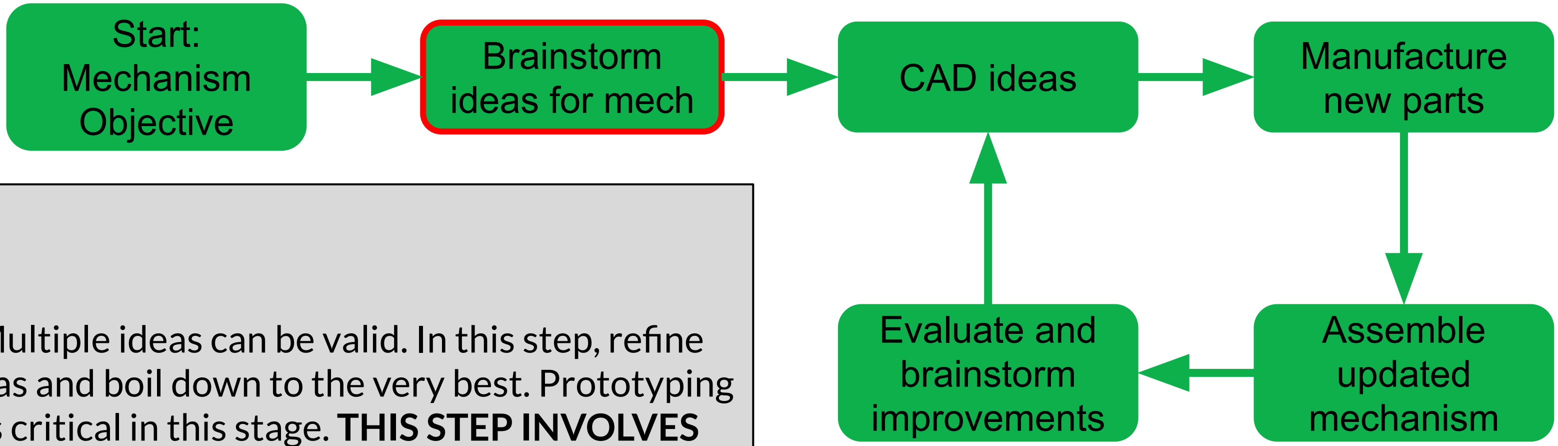


We begin with the mechanism objective. When you evaluate how well your design works, it's all about the OBJECTIVE-

What is the mechanism supposed to do?

Keep the objective in mind throughout the design process!

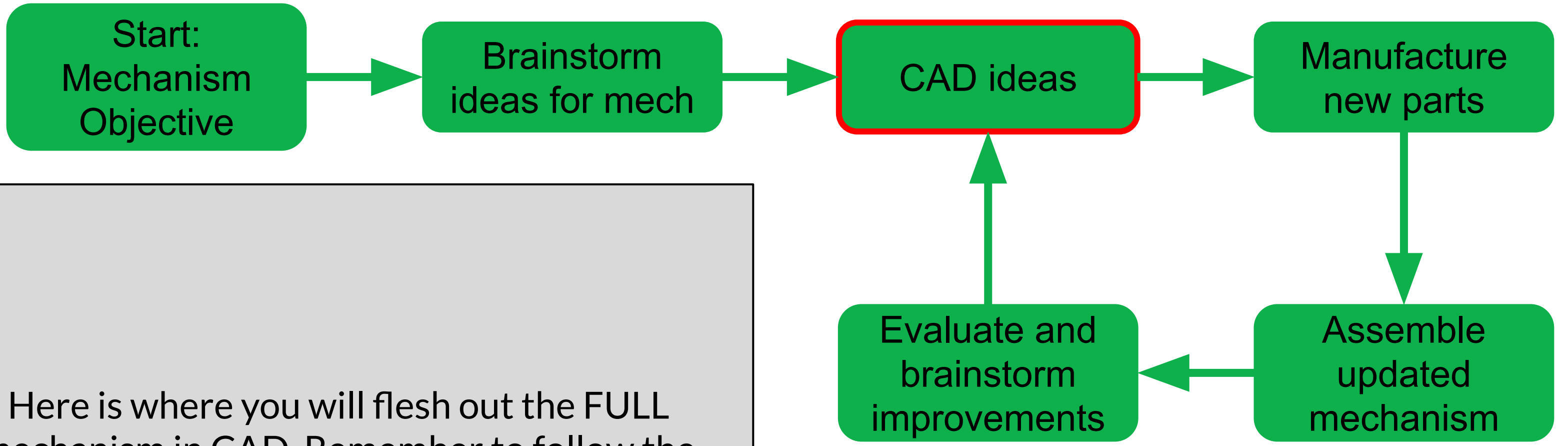
Design Process Workflow



Multiple ideas can be valid. In this step, refine ideas and boil down to the very best. Prototyping is critical in this stage. **THIS STEP INVOLVES <u>LOTS</u> OF INTERNET RESEARCH.**

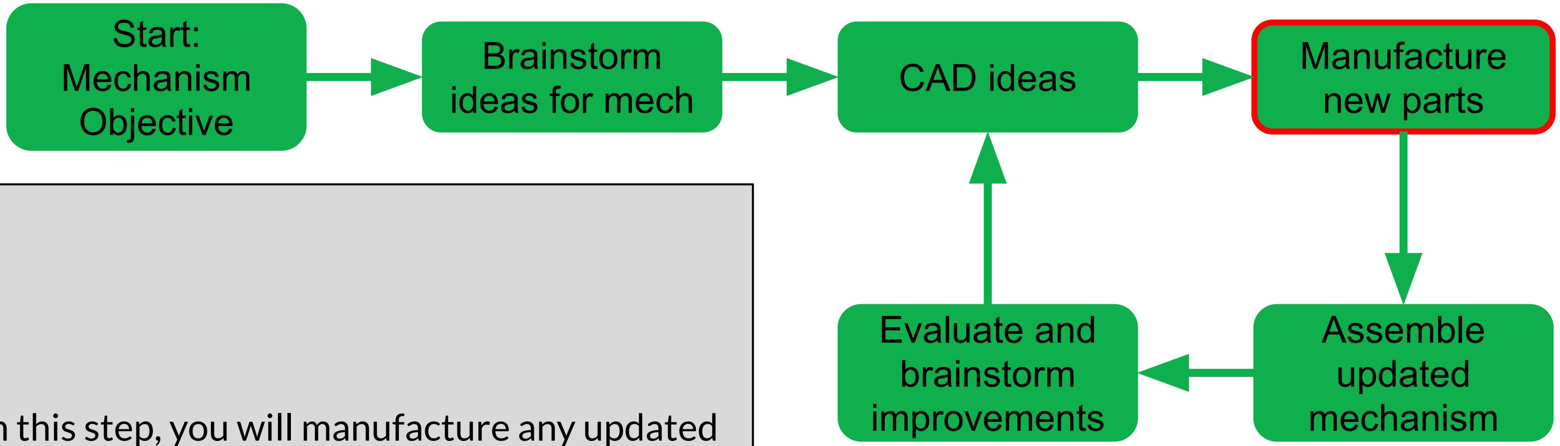
Look to other teams for inspiration!

Design Process Workflow



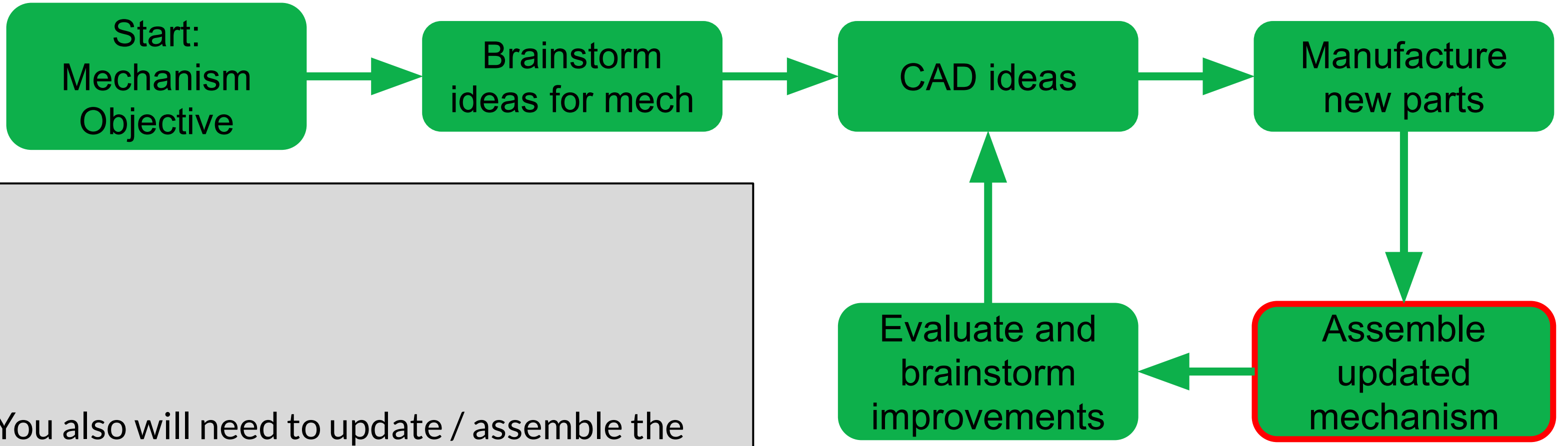
Here is where you will flesh out the FULL mechanism in CAD. Remember to follow the design priorities process as you go through CAD!

Design Process Workflow



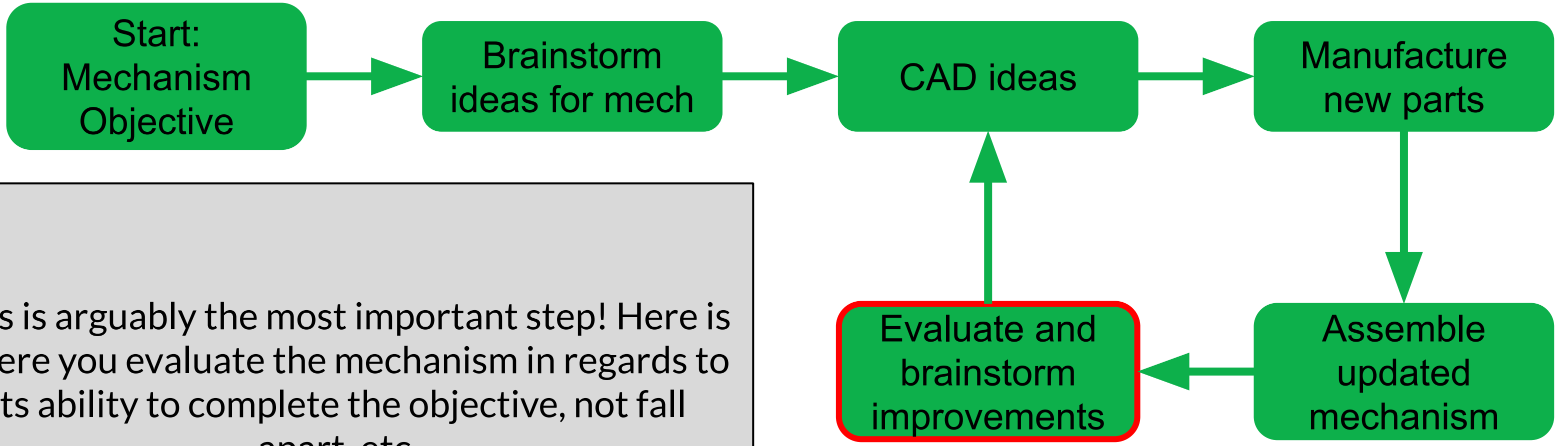
On this step, you will manufacture any updated or new parts for your mechanism.

Design Process Workflow



You also will need to update / assemble the mechanism.

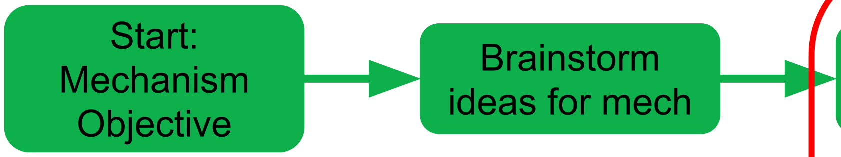
Design Process Workflow

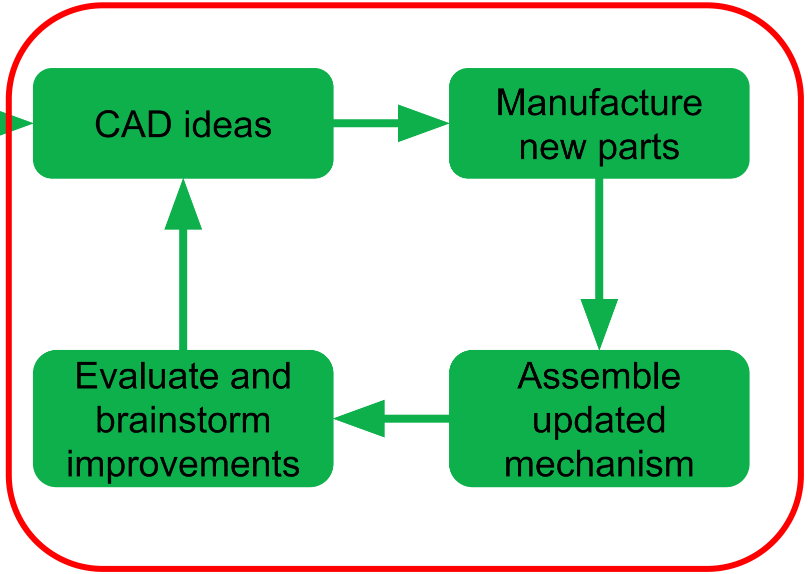


This is arguably the most important step! Here is where you evaluate the mechanism in regards to its ability to complete the objective, not fall apart, etc.

Here is where you **document** and **evaluate** what to change for next time!

Design Process Workflow





In the end, the goal is for you to go through the iterative cycle **many** times before you compete with your mechanism!

It is important to refine your mechanism along the way- objectively evaluating designs and iterating are both key parts of a winning design.

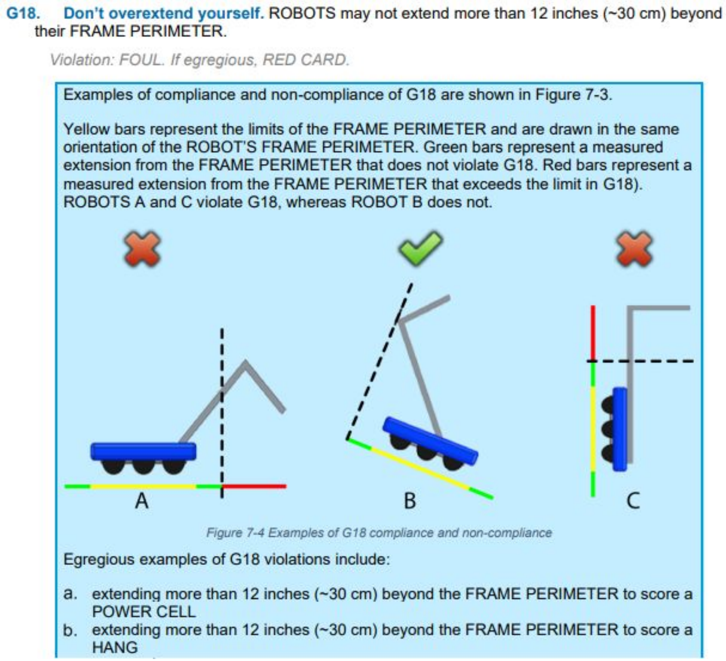
Design Principles

Design Principles

When designing anything, there are always principles one must consider. While these are not absolute, for our team the principles (in order of priority) are:

1. Robot Legality
2. Design for Manufacturing
3. Field Movement
4. Game Piece Manipulation
5. Actuators
6. Structural Design
7. Sensors
8. Electrical
9. Aesthetics

Priority #1: Design Legality


G18. Don't overextend yourself. ROBOTS may not extend more than 12 inches (~30 cm) beyond their FRAME PERIMETER.

Violation: FOUL. If egregious, RED CARD.

Examples of compliance and non-compliance of G18 are shown in Figure 7-3.

Yellow bars represent the limits of the FRAME PERIMETER and are drawn in the same orientation of the ROBOT'S FRAME PERIMETER. Green bars represent a measured extension from the FRAME PERIMETER that does not violate G18. Red bars represent a measured extension from the FRAME PERIMETER that exceeds the limit in G18). ROBOTS A and C violate G18, whereas ROBOT B does not.

Figure 7-4 Examples of G18 compliance and non-compliance

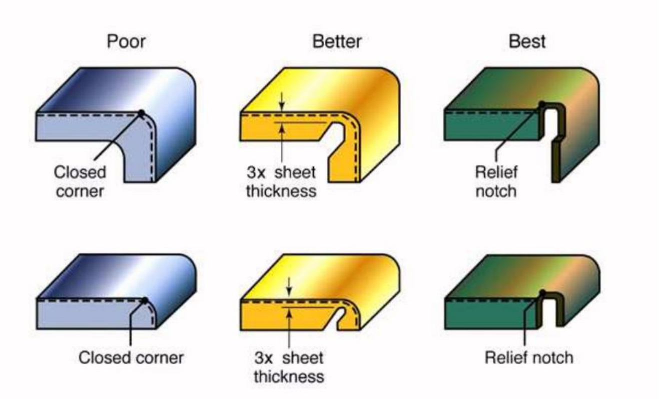
Egregious examples of G18 violations include:

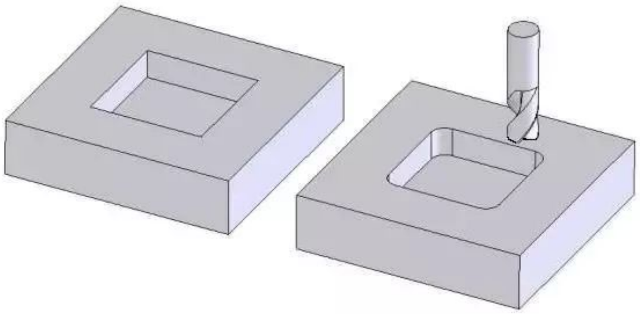
a. extending more than 12 inches (~30 cm) beyond the FRAME PERIMETER to score a POWER CELL
b. extending more than 12 inches (~30 cm) beyond the FRAME PERIMETER to score a HANG

Robot rules as written in the manual

- FIRST competitions all have rules that are both meant for the safety of competitors and to add to the difficulty of the game challenge.
- Our first priority is making sure the robot complies with these rules to be legal for competition.
- If you have the best robot in the world, but it never makes it past field inspection... that is no fun :(

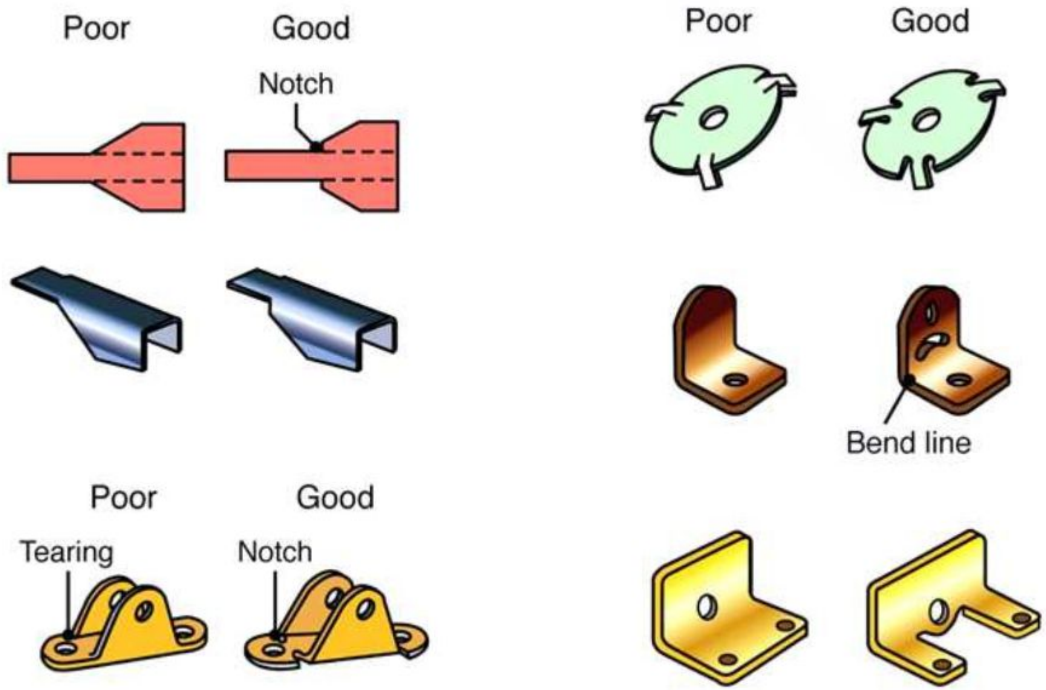
Priority #2: Design for Manufacturing





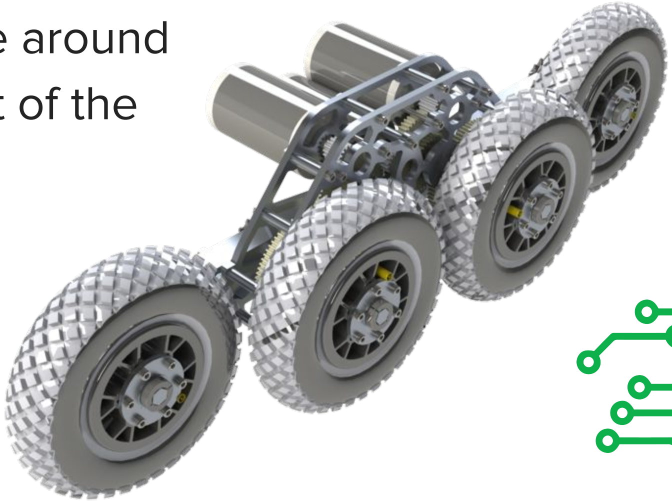
- Why design something if it’s impossible (or very hard) to manufacture?
- Always think about **how** you are going to manufacture the parts you are designing!

More DfM Examples



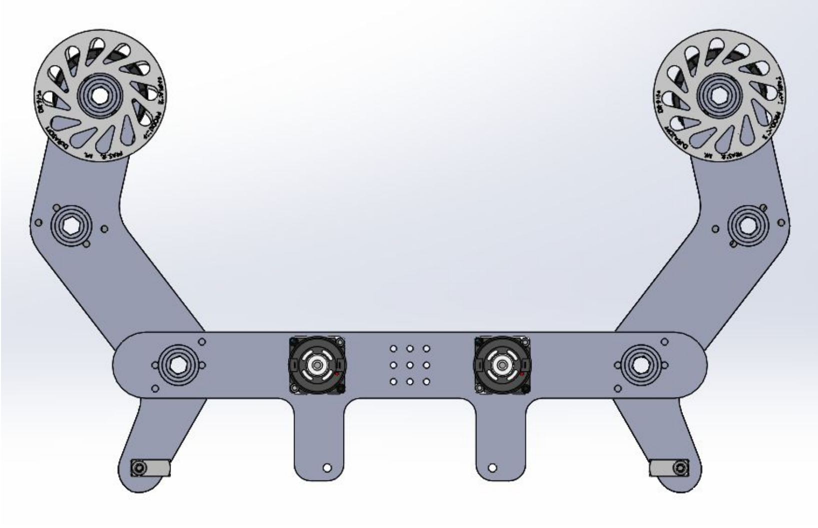
Priority #3: Field Movement

- Getting around the field in a controlled, effective manner is the #1 objective of any FRC/FTC robot!
- Similarly to the legality of the robot, if your mechanisms are the fastest in the world, but your robot can't move around the field quickly or well, then you lose out on a lot of the potential of your designs



Priority #4: Game Piece Manipulation

- FIRST game challenges always have game pieces that are the core of scoring points
- Therefore, creating a mechanism that can quickly and consistently control these pieces on the field is highly necessary for a competitive robot



← What on this manipulator touches the game piece? How does it move?

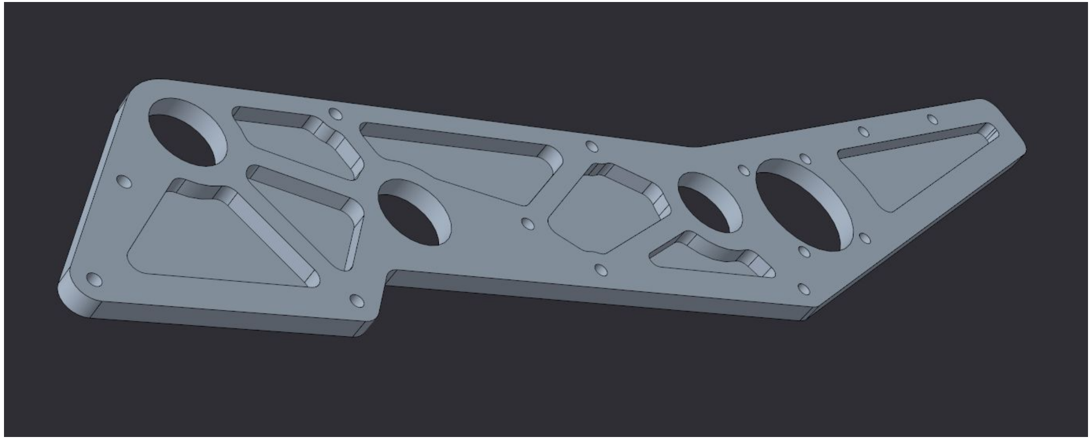
What should be higher priority- the placement of electronics in your robot, or an efficient path for game pieces to move through your robot (i.e. a conveyor system?

Priority #5: Actuators

- All of the moving parts of a robot are run by some kind of motor, servo, pneumatics, etc.
- Making sure there is space in the drive base and on all the mechanisms for the required motors is essential for a streamlined design
- Be sure that your design allows for quick access to these components should they ever need replacement or adjustments

Priority #6: Structural Design

- The structural design and integrity of the robot is essential for the different parts of the robot to hold up during a match
- While this point is a lot lower on the priority (since without proper mechanisms, there is little need for proper structure), that does not take away from its importance in a well balanced design



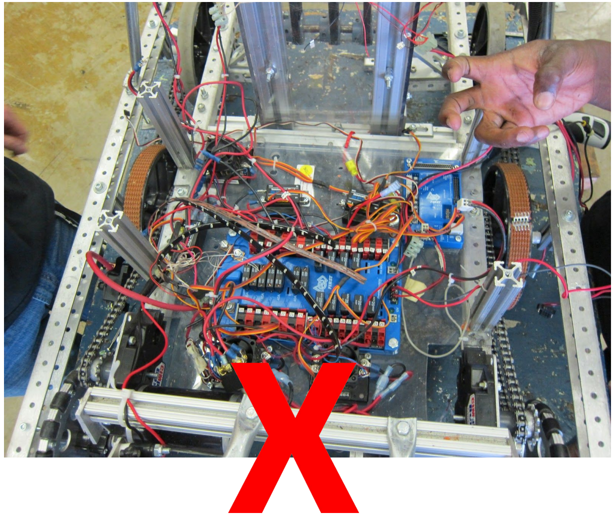
The holes for bearings were already determined from previous steps, but the supporting geometry is thought through in this step.

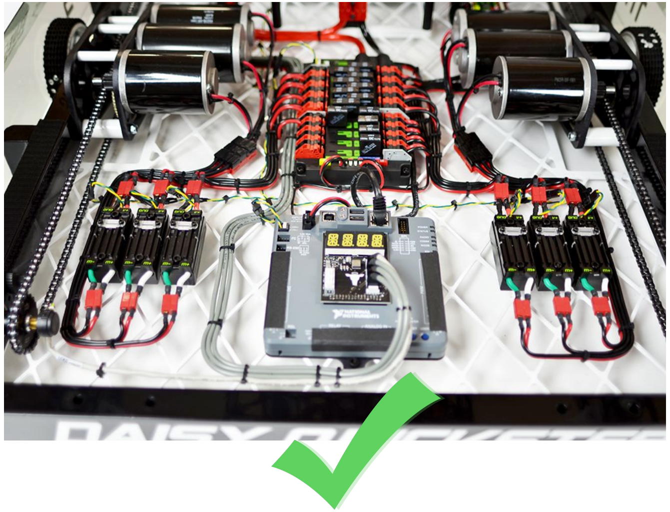
Priority #7: Sensors

- Sensors and other inputs are a great help in allowing for precise movements of the robot as well as taking away some extra responsibilities from the driver during a match.
- Well integrated sensors can sometimes even complete tasks faster and more consistently than a driver
- Sensors also are integral to the autonomous section of the match (in both FTC and FRC) where the robot will have to move entirely on its own

Priority #8: Electrical/Pneumatics

- This encompases the wires and tubes connecting actuators to core robot components
- The goal is for the cables to be as constrained and streamlined as possible to make sure they don’t get in the way of mechanisms and are easy to modify





Priority #9: Aesthetics

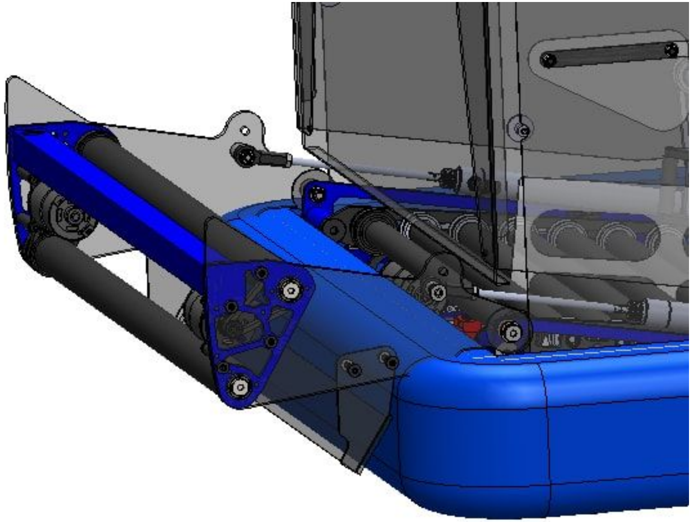
- Aesthetics are an important part of a well-rounded robot and team.
- Find ways to incorporate team design features (logo, design elements, etc.) in your design!

Design Priority Example: Ball Intake Mechanism

Objective: Move a dodgeball from on the ground outside the robot to elevated inside the robot

Initial Idea: Let's have rollers with conveyor belts flip down and pull the ball in

"Steal the best" example:

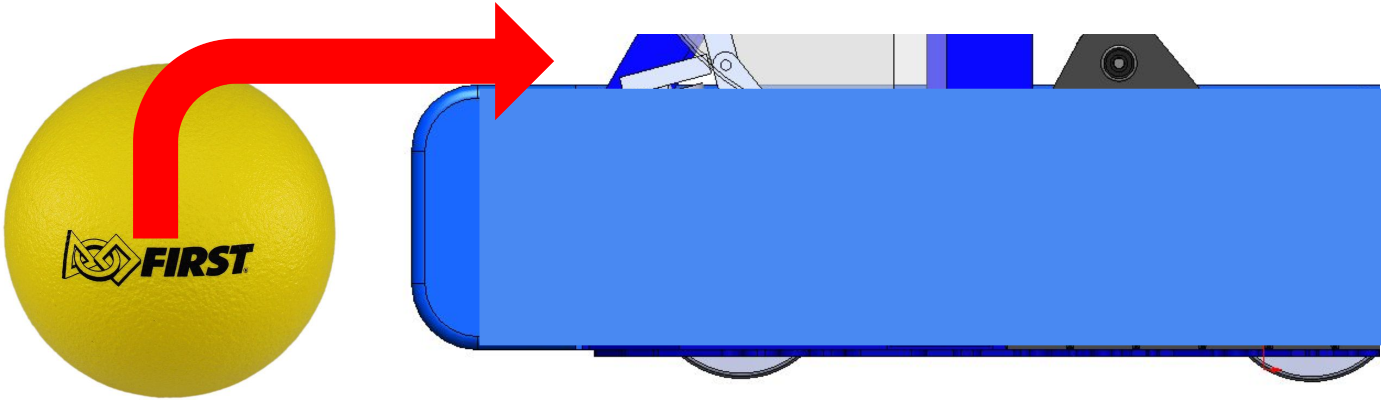


Design Priority Example: Ball Intake Mechanism

Constraints (Priority #1): Can’t extend more than 10 inches out; mechanism has to retract within robot

Priority #2 (DfM): We’ll use a routed polycarb sheet + standoff combo to make the mechanism

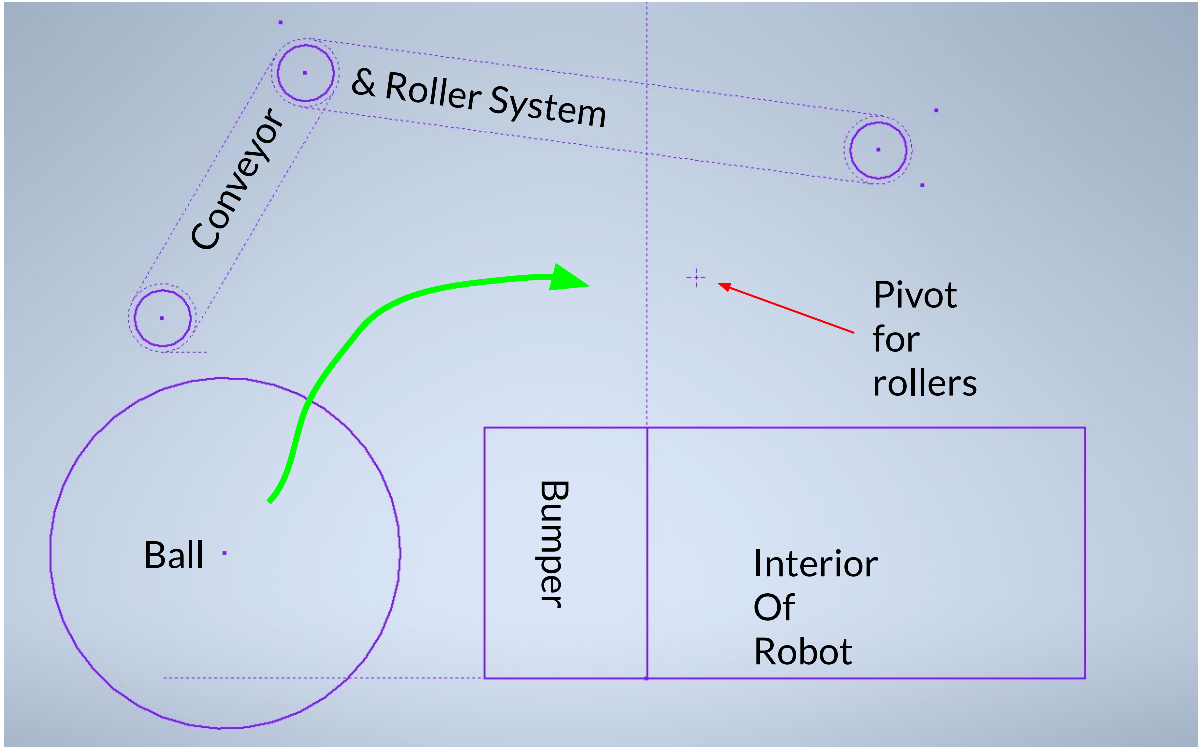
Priority #3: Well, the drive base is already designed.. Done with that :)



Design Priority Example:
Priority #4- Game Piece Manipulation

Here, we need to figure out the path of the ball.

We know that the ball compresses, and that we will need to maintain contact between it and both the rollers and the static ground/robot:



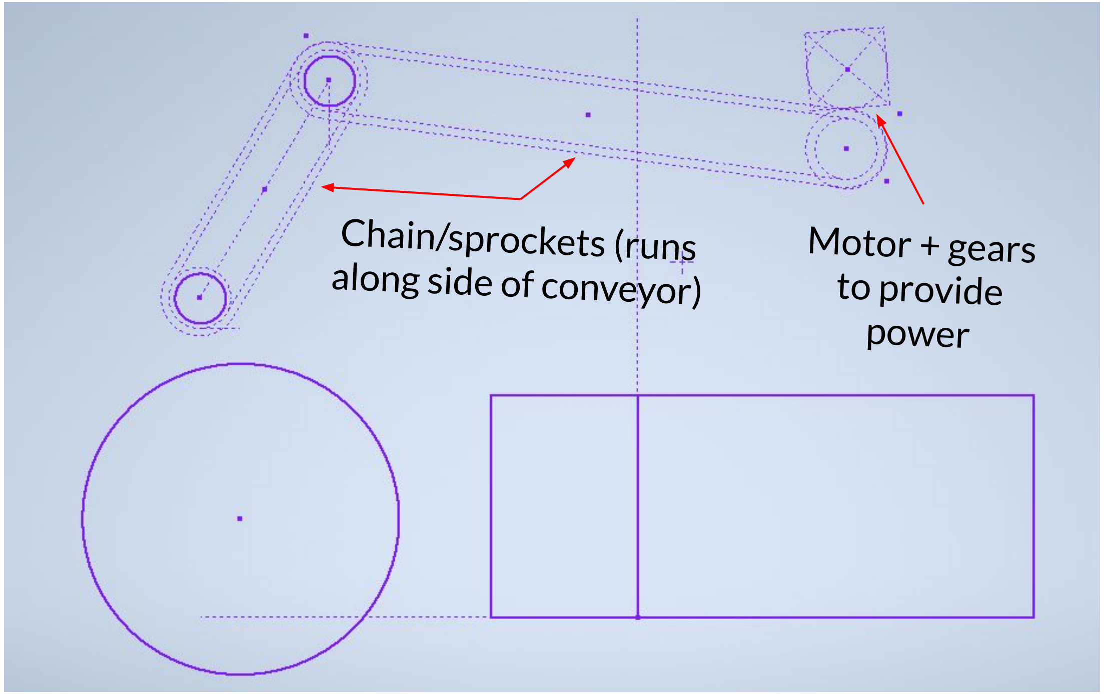
Design Priority Example: Priority #5- Actuators

We know that:

a) A motor is needed to spin the rollers.
b) We should probably power each roller because conveyors are bad at transmitting power.

Based on KISS: let's just use one motor.

That does mean that we need to run a belt/chain/gears between mechanisms.

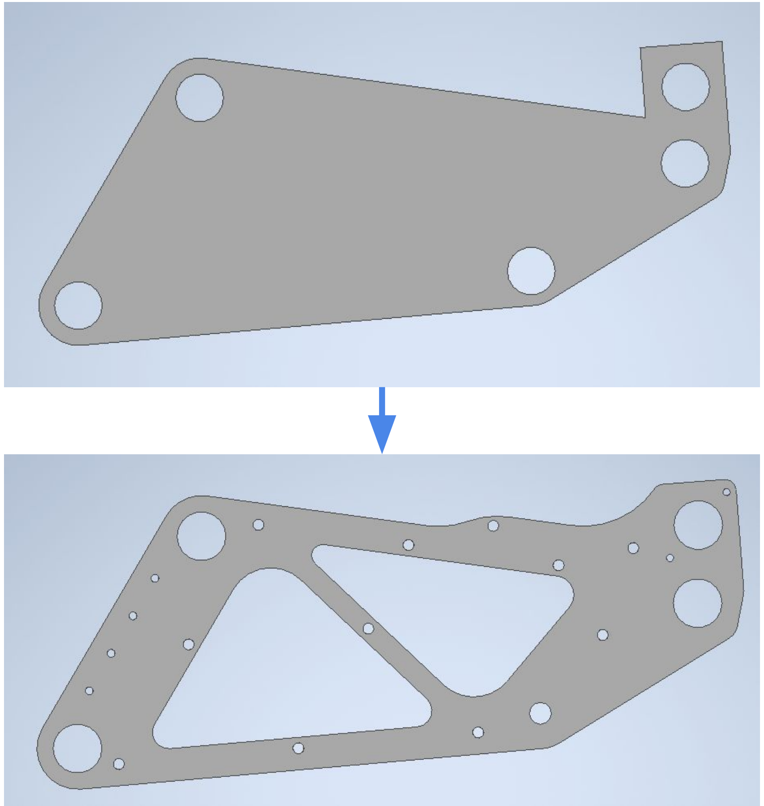


Design Priority Example: Priority #6- Structural Design

Here is where we really start to place things together.

For the design, we know we will have side polycarb plates that locate most components supported by standoffs.

Details such as mounting holes and other structural components are added here

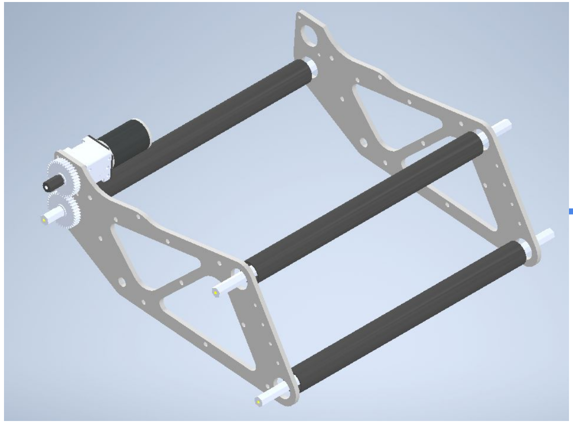


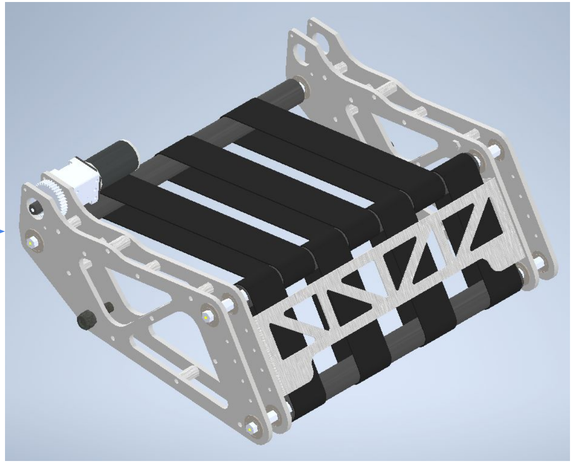
The transition from core features to a manufacturable part- complete with mounting holes and lightening (weight is a constraint!)

Design Priority Example:
Priority #6- Structural Design

We also can start putting together all the moving parts that make the assembly.

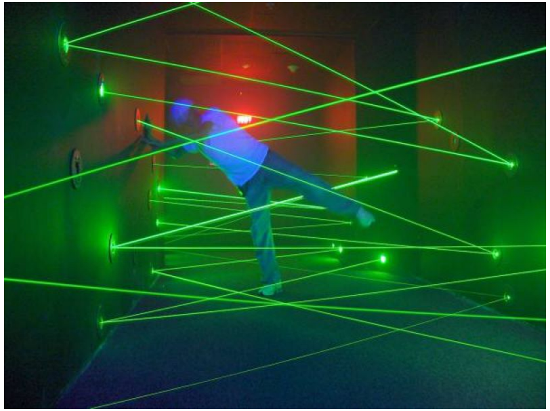
Remember to include as much detail as possible (bearings, axles, etc.) so that way there aren't any forgotten parts when it comes time to build in real life!

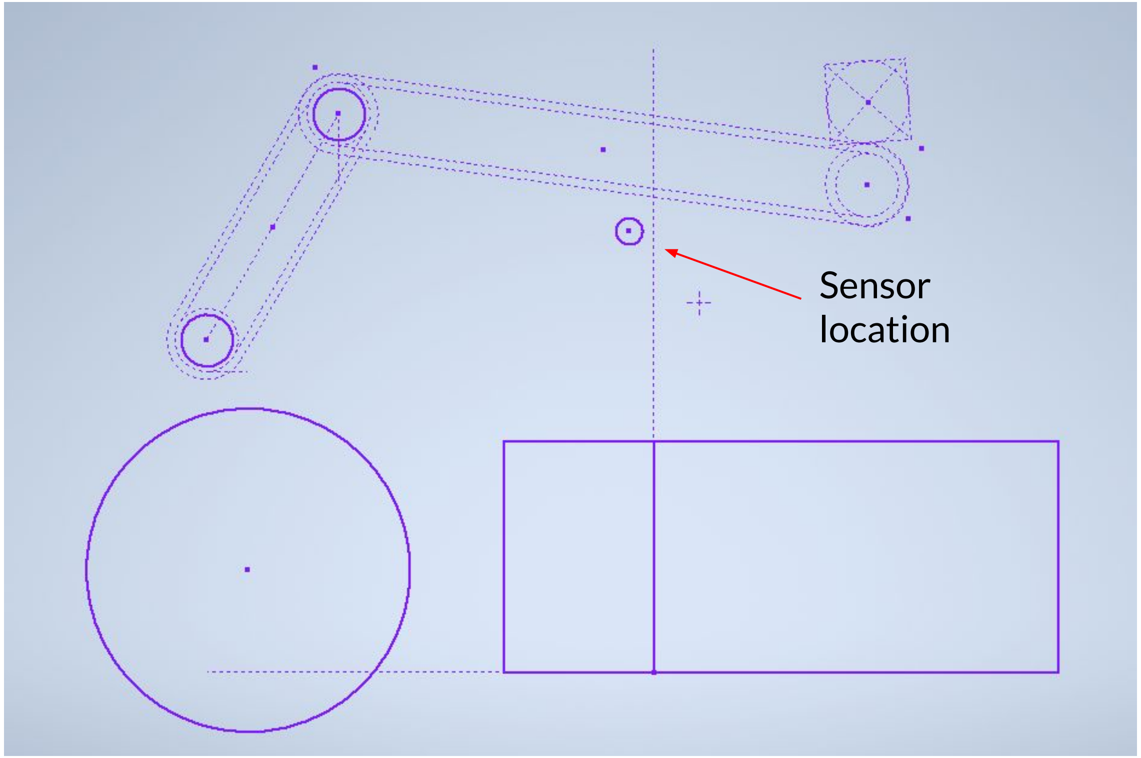




Design Priority Example: Priority #7- Sensors

Here, is where we would add sensors. We decided to add a beam-break sensor that will let us know if a ball crosses the path, like below:

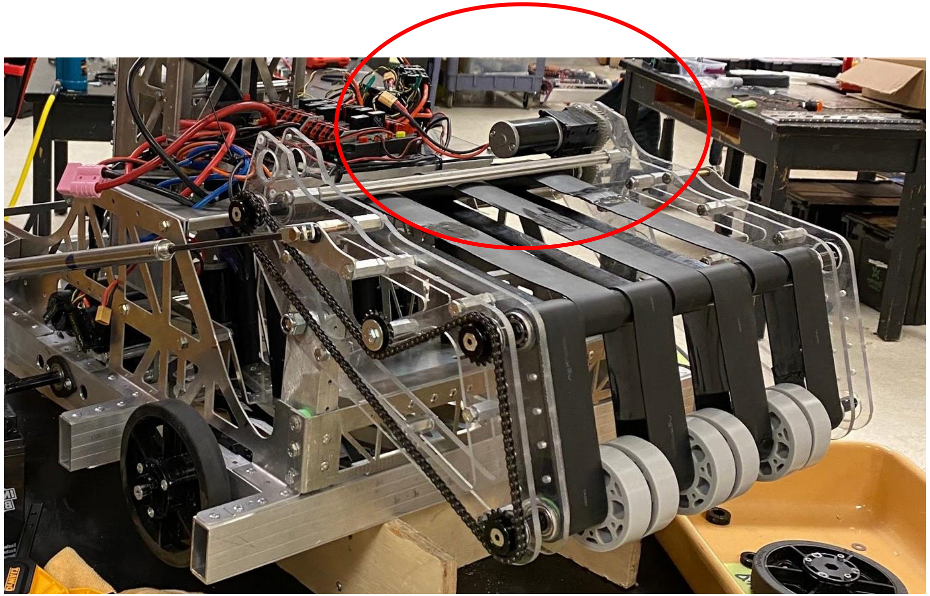




Design Priority Example: Priority #8- Electronics

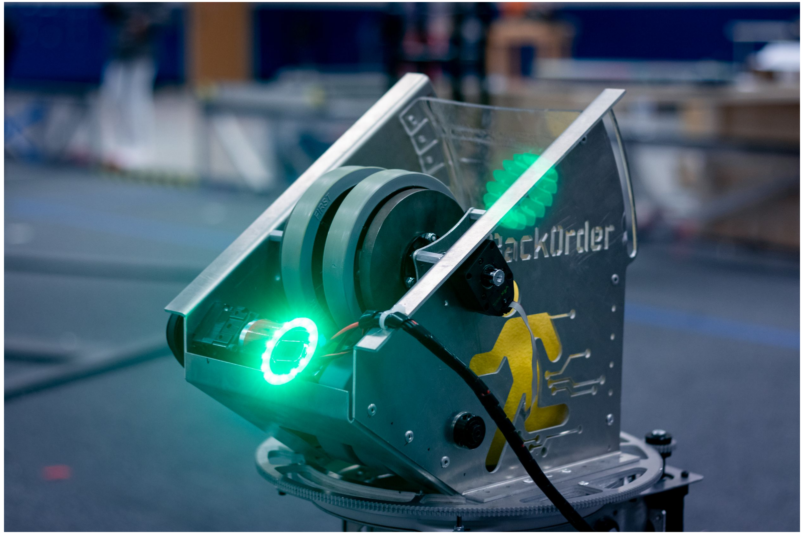
Here, we need to figure out how to prevent the motor wires from getting caught in the mechanism.

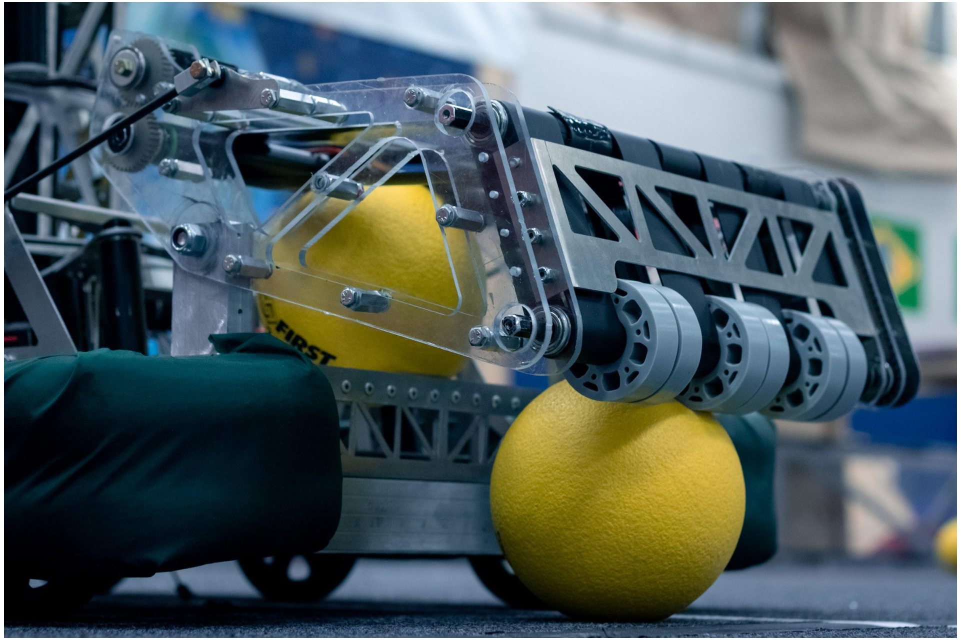
This is often an afterthought... but you can save yourself a big headache if you think this through! (we didn't think about this last season and we had issues!)



Design Priority Example: Priority #9- Aesthetics

- This part looks pretty cool on its own :)
- However, take a look at our shooter plates!



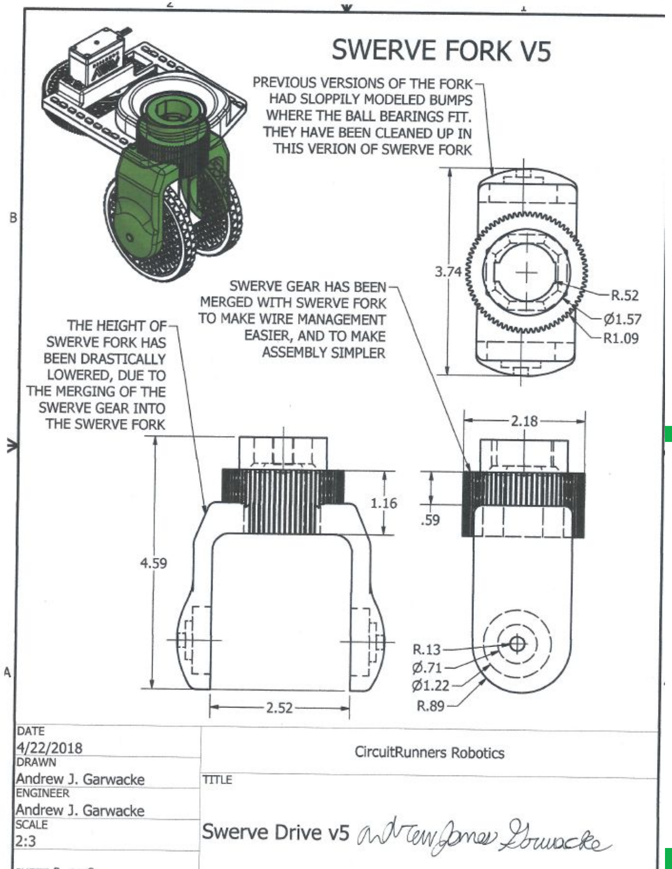


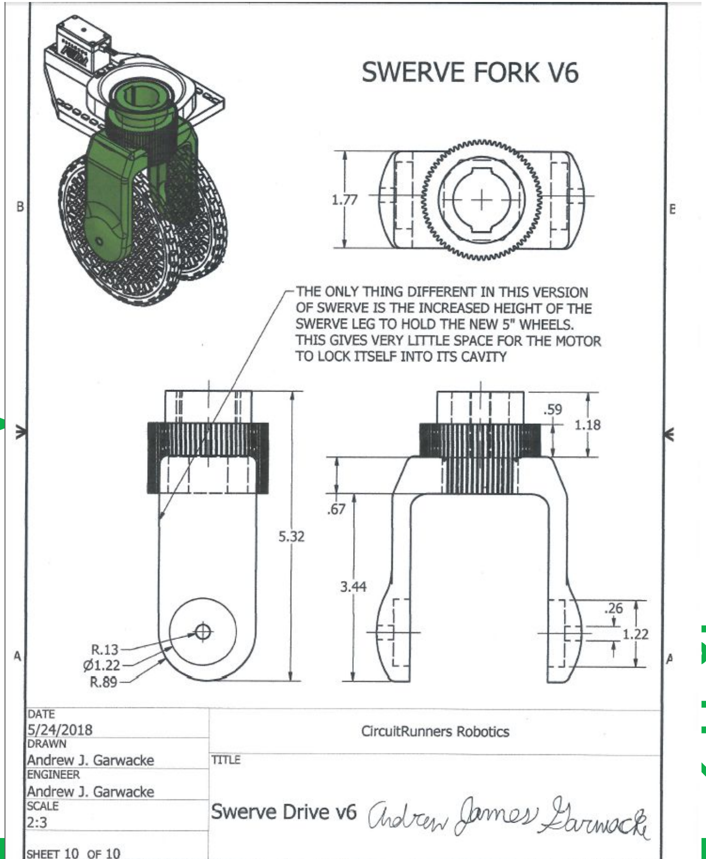
Documentation

Documentation- Changelog

- Documentation can show the engineers’ thought process **from conception to execution**.
- The changelog should show **design changes** and the **resolved and unresolved issues** with each iteration.
- Documentation is vital for the iterative design process.
- Each improvement in the part should learn from the previous iteration successes and failures, and improve upon it in a meaningful way.

Changelog- Documenting Iterations





Documentation- DBS

Design **B**reakdown **S**tructure

- Shows all of the mechanisms, subassemblies, and parts that make up your robot

WHEELER CircuitRunners

Design Breakdown Structure

PART NO	NAME	SUPPLYER / PART NUMBER	FROZEN	TYPE	BUILD	QUANTITY	CAD ISSUE	STATUS	PROJECT OWNER	COMMENT
#311-003	Flywheel			P·	WJ	1		R - RECEIVED		Steel
#320-000	Shooter Gearbox Assembly	VersaDM 4:1 Gearbox with AndyMark 775 Redl		A	O -	1		D - DESIGNED	Teddy	
#320-001	VersaDM Gearbox			H	O -	1		RO - READY TO ORDER	Teddy	
#320-002	AndyMark 775 Redline Motor			H	O -	2		R - RECEIVED	Teddy	0.806 lb
#320-003	VersaDM Gearbox 1/2" Hex Output shaft			H	O -	2		R - RECEIVED	Teddy	Combined with 320-001 for PO Ordering
#320-004	18t MTD Pulley			H	O -	2		O - ORDERED		
#320-005	Shaft collar			P·	O -	1		RO - READY TO ORDER		
#320-006	Gearbox belting			P·	O -	1		D - DESIGNED		

DBS Naming Convention

100-003: Assembly Number-Part Number

000-000: Base robot assembly file

110-000: Subassembly of an assembly

100-000: First subassembly file

100-001: First part in the first assembly

Further info: https://docs.google.com/spreadsheets/d/128Wpo4XdBLgdJdIQkdunVXZnfR8_cnwoAEUtmUquu-w/

Questions? Comments?

Homework for tomorrow…

Think about a FRC mechanism you'd like to design with me!

This could be:

- Ball shooter
- Intake
- Elevator/Arm system
- etc!